## REMARKS

Claims 41-60 are pending, and have been amended in accordance with the helpful recommendations of the Examiner.

In particular, Applicants appreciate the Examiner's indication "In this instance, the applicants are suggested to amend these 'casting mold' claims 41-60 to become 'process for making a casting mold' claims, such that the process steps would impart substantial patentable weight to these claims. It is noted that the applicants had included process claims in the prior amendment of claims 21-40 (that are now cancelled). In summary, process claims with distinct steps of making the casting mold would receive more favorable consideration."

As a result, claims 41-60 are amended to process claims.

**Present invention**

The present invention provides a novel process for manufacturing a mold for metal casting by a rapid prototyping process.

As discussed in paragraph [0032] of the specification, the invention takes advantage of the phenomena that, upon application of heat to a mixture of fine and large particles, particularly if the fine and large particles are of the same material, the fine particles have a "higher sinterability", i.e., they melt and sinter earlier than large particles. They thus can build bridges between large particles, before the large particles melt. Since the large particles do not melt, the form stability of the mold is maintained, and there is little or no sintering shrinkage – a problem encountered when firing a green shape held together with binder to make a mold.

The claimed process produces a mold in such a manner that the mold does not shrink, as compared to the mold materials and processs of Langer, wherein each mold must be designed based on advance calculation of "the amount of shrinkage according to the casting material to be used" (col. 9, lines 39-40).

The end product casting mold is a porous ceramic in the sintered state. Porosity allows off-gassing when casting the metal. Further, by matching the thermal coefficient of expansion (TCE) of the particles matched to the TCE of the metal to be cast, (TCE of the ceramic is above

approximately $8.5*10^{-6}K^{-1}$), the cast metal is not distorted by expansion or contraction of the mold.

In accordance with the invention, the fine particles are sintered by laser sintering either during rapid prototyping process (claim 41 and 42) or after a rapid prototyping process 3D-printing (claim 50).

**Specification**

The Examiner requires removal of "legal" terms from the Abstract, and removal of the recitation "(Fig. 2)".

In response, Applicants amend the Abstract.

The disclosure is objected to. In paragraph [00042] "carbonatious" should be replace with "carbonaceous".

In response, Applicant has reviewed the specification and requests entry of corrections.

**Claim Objections**

Claims 41, 44, 46, 48, 49, 53, and 57-60 are objected to because of the following informalities:

in claim 41, 4th line of section a), delete "the" before "10 fold".

In claim 44, 2nd line, insert "," after "Zr" for clarity.

In claim 46, 2nd line, delete "[0018]" at the end of the claim.

In claims 48 and 49, both claims are improperly dependent upon cancelled claim 21. In claim 53, 3rd line, delete "the" before "10 fold".

In claim 57, 2nd line, insert "a" before "main" for clarity.

In claim 58, 1st line, replace "process" with "casting mold" for consistency with the remainder of the claims.

In claim 58, this claim is improperly dependent upon cancelled claim 30.

In claims 59 and 60, 1st lines of both claims, replace "powder mixture" with "casting mold" for consistency with the remainder of the claims.

In claim 60, this claim is improperly dependent upon cancelled claim 36.

In claim 60, 2nd line, insert "," after "Al" for clarity. In claim 60, last line, delete "," before "and/or" for clarity.

In response, Applicant has amended the claims according to the Examiner's helpful suggestions.

**Claim Rejections - 35 USC § 103**

Claims 41-60 are rejected under 35 U.S.C. §103(a) as being obvious over Langer et al. (US 6,155,331) in view of Noll et al. (US 4,938,802).

Langer et al. (col. 3, lines 14+) is cited for disclosing a ceramic casting mold for use in precision casting, in which the casting mold 6 (see Figure 8) is comprised of a compositional mixture of a first material that is chemically inert (e.g. silica sand and zirconic sand) and a second material (e.g. organic binder) that is curable by a chemical curing process such that the compositional mixture of first and second materials undergoes a melting/sintering process by an electromagnetic radiation device 7 (e.g. laser sintering), with a rapid prototyping process being used (in one embodiment — see column 9, lines 17-55) for manufacture of the casting mold (abstract; column 8, lines 56-67; column 9, lines 1-67; column 10, lines 1-58; and Figures 1-8). Langer et al. do not specifically disclose values/ranges of the thermal coefficient of expansion of the ceramic mold.

Langer does not teach that the thermal coefficient of expansion of the ceramic mold is above approximately $8.5*10^{-6}K^{-1}$. For this, the Examiner cites Noll et al.

Applicants respectfully traverse.

Langer teach forming a mold using a molding material comprising a first material and a second material, said first material being chemically inert when irradiated by electromagnetic

radiation and said second material being curable by a chemical curing process which is initiated by electromagnetic radiation.

The mold of Langer is chemically and physically different from the sintered mold of the present invention. In Langer the molding material is made of a first material and a second material. The first material is chemically inert when irradiated by electromagnetic radiation. The second material is curable by a chemical curing process that is initiated by electromagnetic radiation. As disclosed in col. 10, lines 48-58: "When irradiating care should be taken that an amount of energy sufficient for initiating the chemical curing reaction (polycondensation, s.a.) is entered into the molding material to be cured; otherwise the particles of molding material are only reversibly pasted together by superficial sintering which causes destruction of the cast part under later heat action (e.g. at an external post-curing process in a furnace, but certainly at the second cast) by decomposition of the sintered composite. Such cast parts produced without the proper chemical curing mechanism can not be used in casting."

In any case, Langer does not teach the presently claimed process.

The Examiner indicates that it is further known to use fusable particles which can be applied layerwise, in analogy to the selective laser sintering process, fused in each layer corresponding to the contour of the part to be produced by using a laser and by sintering form the part to be produced. However, it is not known that correspondingly produced objects can be used as lost molds and cores in sand casting metals (U.S. Pat. No. 4,247,508).

Regarding the (product/article-by-process) "casting mold" claims 41-60 (casting mold made by the "generative rapid prototype" process of independent claim 41, and made by the "3D binder printing" process of independent claim 50), it is the Examiner's position that the casting mold of Langer et al. in view of Noll et al. would be identical to or only slightly different than the claimed casting mold prepared by the method of the claim(s). Importantly, the coarse particles, fine particles, and organic binder would all undergo a change of structural characteristics upon melting and/or sintering to form the casting mold (product).

In this instance, the Examiner advises Applicants to amend these "casting mold" claims 41-60 to become "process for making a casting mold" claims, such that the process steps would impart substantial patentable weight to these claims. It is noted that the applicants had included

process claims in the prior amendment of claims 21-40 (that are now cancelled). In summary, process claims with distinct steps of making the casting mold would receive more favorable consideration.

In response, Applicants have amended the claims to method claims.

As already discussed in the response to the previous Office action, the object of the present invention is to guarantee a sufficiently good dimensional stability of the casting mold. This object is achieved by the additional application of fine particles, through which the temperature required for the sintering compound of the coarse particles is lowered, especially shrinkage is reduced.

Langer et al. disclose a totally different alternative solution, namely the compound of the particles, over which the heat-hardened resin binder is coated, is not sintered. This results over the prior art the advantage of reduced material shrinkage and warp (see column 13, lines 27-31).

Langer et al. disclose a ceramic casting mold, which is produced by a rapid process and is in a not-sintered green state. The ceramic consists of molding sand, which is coated with heat-hardened resin binder. The mold strength is provided by the hardened binder, not by the sintering. Clearly, Langer et al. do not disclose

- sintering
- porous ceramic
- fine particles
- expansion coefficient

It appears from the Examiner's comments that the Examiner recognizes the differences between the presently claimed process and the processes set forth in Langer and Noll, and for this reason advises Applicants to once again claim the invention in terms of the process.

Accordingly, Applicants herewith claim the process, reserving the right to file a continuation application directed to the product by process.

Withdrawal of the rejection is respectfully requested.

The Commissioner is hereby authorized to charge any fees which may be required at any time during the prosecution of this application without specific authorization, or credit any overpayment, to Deposit Account Number 16-0877.

**Should further issues remain prior to allowance, the Examiner is respectfully requested to contact the undersigned at the indicated telephone number.**

Respectfully submitted,

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